

Deforestation and Degradation of Natural Resources in Ethiopia: Forest Management Implications from a Case Study in the Belete-Gera Forest

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The major causes of deforestation and degradation of natural resources in the Belete-Gera Forest of Ethiopia are coffee production activities and encroachment into forestland to expand farmland and pasture. Population growth, and the government's land-reform and re-settlement programs have caused local residents to lose harmony with the land. Forest management in this area hasn't yet been fully developed. The objectives of this study are to identify the extent of deforestation and natural resource degradation, in preparation for a sound management plan. Encroachment of farmland and pasture into natural forest during the past four years has been identified through interviews and aerial photo interpretation. The encroachment rate is 1.45% per year. Encroachment occurred mostly on areas with gentle slopes adjacent to populated villages and along roads and footpaths. The extent and impact of coffee production activities were examined through agency documents, forest survey data and vegetation survey. It is estimated that up to 49% of the accessible natural forest is under the influence of coffee production activities, among which collecting of naturally grown coffee beans has the least and the coffee plantations has the most impact on the natural forest. Coffee plantations in natural forest have reduced the forest density and species diversity. Age structure of the trees is limited to mature and old classes only, which eventually endangers their function as shade for coffee plantations.

Key words: Africa, coffee, deforestation, encroachment, Ethiopia

Coverage of natural forest in Ethiopia has been decreasing at an alarming rate, from 40% of the land area (50 million ha) just before the turn of this century to 3.6% by the early 1980s. By 1988 it had declined to 2.7% (3.2 million ha) (Transitional Government of Ethiopian, 1994). The rapid loss of forestland has raised the concerns of local, national, and international communities. Many local communities now work harder to collect firewood and construction materials. In some villages women spend six hours, walking 10 km each way, to collect firewood.

To cope with the rapid depletion of forests, the Transitional Government of Ethiopia (established in 1991 after the collapse of the socialist regime) issued the "Forest Conservation, Development and Utilization Proclamation" on March 28, 1994. At about the same time (December, 1994), the Ethiopian Forestry Action Program (EFAP), the equivalent of Tropical Forestry Action Plan, with the help of many international organizations, such as the World Bank, United Nation Development Program, was completed.

EFAP states that the effective management of the remaining forest resources depends on the design and implementation of a comprehensive program to survey and inventory the country's forest resources. It urges the formulation of a "Forest Management Plan" as part of the "Forest Resource and Ecosystem Management Program."

Back in 1989, 58 National Forest Priority Areas (NFPAs) were established. The central government was identified as the lead agency to manage and formulate forest management plans for all NFPAs. By 1994, only four forest management plans had been formulated.

The Japan International Cooperation Agency (JICA) was asked to assist with developing forest management plans for

the country in 1994 and the Belete-Gera National Forest Priority Area (hereafter referred as Belete-Gera Forest) in the southwestern part of the country was selected. This paper is based on the study conducted in the region and partially upon the Final Report submitted to JICA and the Government of Ethiopia.

Objectives of the study are to understand the current situation of deforestation and deterioration of natural resources to provide information for a sound forest management plan.

Study site

Belete-Gera Forest is 150,000 ha in size and is located in the southwestern part of Ethiopia, approximately 50 km to the west of Jimma. It is a highland area in the Jimma Zone of Oromia Region.

Belete-Gera Forest consists of two disjunct forests (Fig. 1). Belete Forest (35,434 ha) is located in Seka Chekorsa District and most of Gera Forest (113,514 ha) is in Gera District. The population in Belete Forest area is approximately 48,772 individuals living in 11,012 households, and that of the Gera Forest area is 27,799 in 6,371 households.

The average annual temperature is about 20°C and the annual precipitation is approximately 1,500 mm. Topographically, the Belete-Gera Forest consists of undulating hills in the 1,000–3,000 m range with steep mountainous terrain in some places.

In Belete-Gera Forest soils are generally fine-textured. Nitisols and Cambisols, often more than 100 cm deep, occur in areas with gentle slopes and forest cover. Leptosols are found on mountain peaks, steep slopes and stream banks where soil is shallow (less than 30 cm deep). Luvisols dominate in depressions such as marshes and lowlands along rivers.

Natural vegetation in the area is mainly highland rain forest with small areas of pure bamboo thicket (*Arundinaria*

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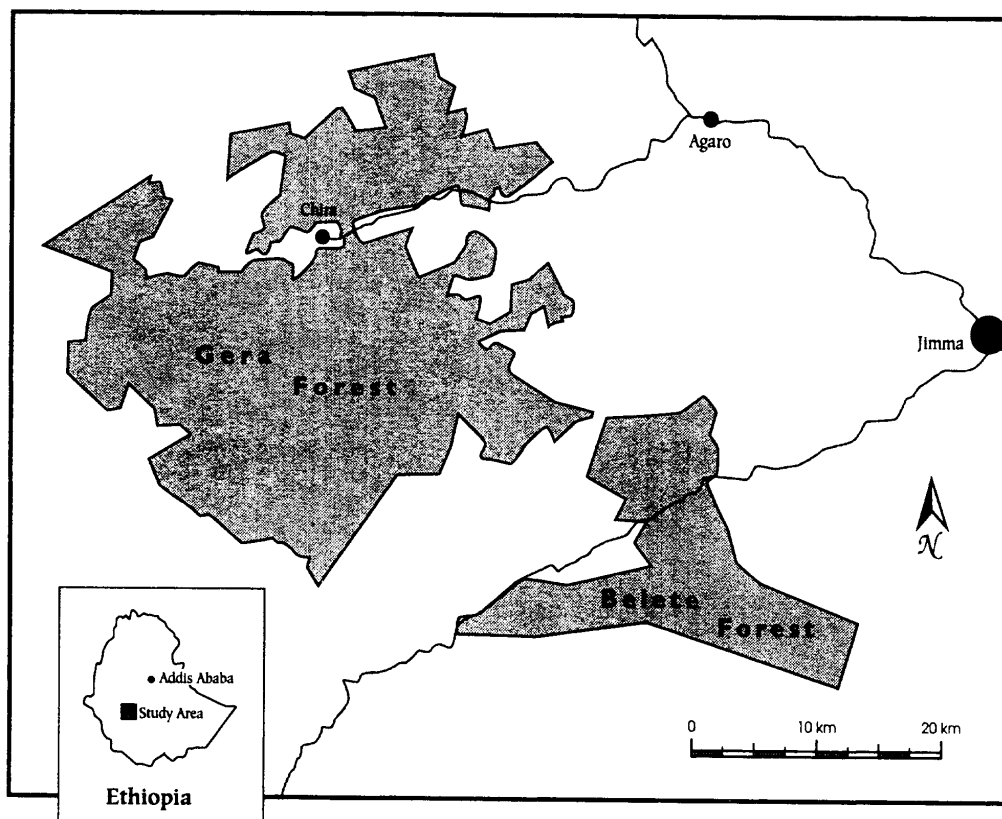


Fig. 1 Location map of Belete-Gera Forest.

*alpina*¹) at high altitudes. Major species are *Polyscias fulva*, *Manilkara butugi*, *Olea capensis* subsp. *hochstetteri*, *Syzygium guineense*, *Bersama abyssinica* subsp. *abyssinica*, *Millettia ferruginea*, *Albizia gummifera*, *A. grandibracteata*, *Aningeria adolfi-friedericii*, *Croton macrostachyus*, and *Macaranga capensis*. Four indigenous species, *Juniperus procera*, *Podocarpus falcatus*, *Hagenia abyssinica*, and *Cordia africana*, have been heavily selectively harvested and have become endangered. At the present time, cutting of these four species is prohibited.

The natural forest is utilized by local residents for firewood, livestock grazing, bark (*Podocarpus falcatus* for apiculture), medicinal herbs, and coffee production. Currently, collecting firewood is allowed, but only dead trees and branches can be collected. Grazing in natural forest is prohibited and restricted to plantations. Debarking *Podocarpus* is illegal, but the law is not fully enforced.

Coffee (*Coffea africana*) is a native species and grows wild in the natural forest. It has been the major cash crop for the region and country. Coffee production activities in the forest range from collecting coffee beans without disturbing the forest to coffee plantations which significantly open up the forest. Coffee production is more prevalent in the Gera Forest area than in the Belete Forest area.

Currently, undisturbed closed highland rain forest can only

be found in mountainous areas far from villages. Most of the accessible forest has been heavily disturbed. Selective cutting, encroachment of farming, grazing and coffee production has reduced the area of forest cover and caused deterioration of the forest. Enrichment plantings of indigenous species on the selective cutting sites have been carried out with some success. Encroachment of natural forest and the coffee production activities are major challenges to forest management.

Method

The current level of encroachment in the area was investigated by analyzing aerial photographs and interviewing local foresters. Local foresters were asked to identify the encroachment areas on aerial photographs based on their knowledge. Their information is limited to accessible areas and those that have been frequently visited. It is also limited to the foresters' service time, of which the longest is four years. Encroachment areas were also identified on aerial photographs by their distinguishing size, shape, and soil color. Recently (within two or three years) cleared forest land has a higher soil moisture content, and therefore appears as a darker color on the aerial photographs, in comparison to areas that have been cleared for a longer time. An encroachment map was created and an inventory of each encroachment area, including location, size, slope, surrounding vegetation type, was generated.

Based on a preliminary field reconnaissance, coffee production activities were grouped into three types according to intensity of forest manipulation: (1) coffee plantation, in which farmers systematically remove trees and plant coffee in

¹ All scientific names are in accordance with Bekele-Tesemma *et al.* (1993), except for species not listed in the book. Kekecha (1987), Fichtl and Adi (1994), and Thirakul (1993) are referred for those species.

Table 1 Summary of encroachment areas.

	Belete Forest		Gera Forest	
	Marginal # (ha)	Satellite # (ha)	Marginal # (ha)	Satellite # (ha)
Size(ha)				
1-4	6 (20)	5 (10)	23 (60)	52 (151)
5-8	4 (24)	2 (12)	18 (113)	40 (261)
9-12	1 (10)	1 (11)	18 (184)	12 (129)
13-16	5 (74)	-	4 (58)	10 (142)
17-20	2 (36)	-	9 (160)	3 (56)
21-40	9 (265)	4 (119)	18 (526)	5 (139)
41-80	2 (136)	2 (119)	7 (367)	5 (252)
81-160	8 (915)	-	6 (756)	2 (204)
> 161	3 (1571)	-	3 (851)	2 (884)
Total	40 (3051)	14 (271)	106 (3075)	131 (2218)
Vegetation				
Un-disturbed	3 (19)	-	11 (63)	38 (200)
Slightly disturbed	2 (150)	-	15 (131)	49 (262)
Heavily disturbed	3 (93)	11 (116)	13 (99)	53 (1268)
Bamboo thicket		-	1 (7)	4 (24)
Others	39 (2789)	3 (155)	88 (2775)	6 (464)
Total*	47 (3051)	14 (271)	128 (3075)	150 (2218)
Slope				
0-2%	-	-	-	-
3-8%	1 (4)	-	13 (103)	29 (125)
9-15%	6 (101)	3 (11)	74 (1195)	62 (513)
16-30%	12 (362)	3 (7)	31 (1384)	44 (836)
31-50%	15 (620)	3 (112)	10 (393)	14 (736)
> 51%	13 (1964)	5 (141)	-	1 (8)
Total*	47 (3051)	14 (271)	128 (3075)	150 (2218)

*Total count exceed the total number of encroachment areas, since one encroachment area may contain several vegetation types and slopes.

the natural forest; (2) collecting naturally grown coffee beans with manipulation, in which farmers not only collect coffee beans but also remove overstory trees and shrubs to increase the productivity; (3) collecting coffee beans from naturally grown coffee without forest manipulation. Typical sites of each type were visited and surveyed to understand the influence of these activities on the forest. Other information was gathered from the District Agriculture Development Office (DADO) and the forest survey data to determine the extent and impacts of coffee production activities on natural forest.

A Standard Plot Survey method was employed. A 40 m by 40 m plot was established and trees with dbh (diameter at breast height) greater than 10 cm in the plot were recorded with species, dbh and height. A subplot of 10 m by 10 m was established within the plot and all species of small trees and shrubs were tallied.

Two coffee plantation sites (type 1) in Belete Forest and five coffee collecting sites in Gera Forest were surveyed. Among the five coffee collecting sites, two are unmanipulated (type 3) with open access (any person can come in and collect coffee beans), three sites have collecting right claimed and have received some managerial care (type 2). Coffee collecting sites with intensive management of the forest could not be studied due to poor weather and road condition.

Results and Discussion

1 Causes

The major reason for the encroachment into natural forest is the need of local people for farmland and grazing fields to accommodate increased population. Other contributing reasons include the lack of awareness about environmental protection, lack of incentives to plant trees, and weak government forest management.

Population growth in the region has been intensified through high birth rate in the past two decades and Ethiopia's re-settlement program which brought settlers in from other regions. Since settlers are mostly from non-forested areas, they do not perceive the value of the forest in the same way as long time residents.

Following the revolution in 1974, when a socialist military junta took over the government, a land reform program took place (Rural Land Proclamation of March 1975). In this reform, farmlands were re-divided, villages were re-organized and Peasant Associations (PAs) were formed. However, individual farmers were not granted private land/tree tenure and local residents' harmony with the land was changed. Farmers often express their unwillingness to plant trees, because they will not receive any benefits from the trees. Some villages have community forest, from which villagers can collect dead branches for firewood or construction wood after obtaining permission from the PA. Most of the villages nearby the Belete-Gera Forest do not have community forest.

Government forest management in the region is limited by personnel and funding. Patrolling and law enforcement to control encroachment are conducted by a few forest guards traveling on foot. Conflicts often occur on poorly marked boundary lines.

Jurisdiction over coffee production in the forest is shared by three groups: the DADO, PA, and the Jimma Zonal Agriculture Development Office (JZADO) and lines of authorities are unclear. The DADO promotes and provides assistance for coffee planting in the forest, PA grants (and receives fees from) farmers for the right to collect coffee beans or plant coffee in the forest, and the JZADO is charged with protecting and managing the forest.

2 Encroachment

Encroachment occurs in two ways; (1) farmers gradually clear the forest using fire and/or debarking large trees, (2) farmers claim a logged site.

In this study we identified and mapped 291 encroachment areas (237 in Gera and 54 in Belete Forest). Sizes range from 1 ha to 1,099 ha. A total of 8,615 ha, 5.8% of the Belete-Gera Forest (3,322 ha, 9.5% of the Belete Forest and 5,293 ha, 4.7% of the Gera Forest) have been encroached during the past four years. The annual rate is 2,154 ha or 1.45%. An inventory of encroachment areas was created and the summary is listed in Table 1.

Most of the encroachment occurred in areas with gentle slopes along roads, footpaths, and populated villages. Logged sites with newly opened up forest roads were most susceptible

Table 2 Comparison of forest density and species composition between coffee production sites and undisturbed forest with naturally grown coffee in the understory.

	Number of species					Number of					
	Total	u**	m**	l**	un***	Trees			Coffee*		
						Total	u	m	l	Natural	Planted
Belete Forest:											
1st year plantation	7	3	4	2	(4)	20	4	7	9	(26)	(35)
4th year plantation	6	3	4	1	(0)	12	5	6	1	(0)	(28)
Undisturbed forest:											
Plot no. 56	20	2	9	17		65	6	16	43	present	
Plot no. 57	12	9	8	5		53	18	23	12	(2)	
Plot no. 62	12	7	5	6		43	17	11	15	(2)	
Plot no. 68	11	4	3	10		60	6	10	44	(1)	
Gera Forest:											
Collecting only (1)	11	6	4	5	(7)	38	8	7	23	(28)	(0)
Collecting only (2)	9	5	2	8	(8)	45	10	3	32	(47)	(0)
Collecting/min. management (1)	13	7	5	9	(5)	50	17	12	20	(241)	(0)
Collecting/min. management (2)	14	6	4	9	(5)	43	12	7	24	(224)	(0)
Collecting/min. management (3)	11	2	4	7	(7)	51	2	7	42	(62)	(0)
Undisturbed forest:											
Plot no. 5	10	3	6	6		55	12	13	30	(16)	
Plot no. 9	18	7	5	12		61	20	11	30	(63)	
Plot no. 11	11	7	4	7		74	15	12	47	present	
Plot no. 12	13	4	8	8		52	14	17	21	(62)	
Plot no. 13	8	2	7	6		33	11	13	9	(73)	
Plot no. 39	8	2	3	7		72	19	7	46	(1)	
Plot no. 47	13	4	8	10		60	8	25	27	(1)	
Plot no. 48	12	4	7	10		61	18	17	26	(32)	
Plot no. 49	11	7	5	7		46	18	13	15	(185)	
Plot no. 50	15	4	8	11		99	21	23	55	present	
Plot no. 52	11	6	3	7		56	23	23	10	(102)	
Plot no. 53	12	3	9	7		141	21	47	73	present	
Plot no. 54	11	4	9	7		56	16	26	14	(1)	

*Plot size, 10 m × 10 m, numbers in parentheses are for reference only. ** u, upper layer; m, middle layer; l, lower layer (plot size, 40 m × 40 m); un, understory.

to encroachment. But no encroachment was observed in cut-over sites where artificial regeneration was conducted shortly after logging.

While examining the locations of encroachment areas, two patterns became apparent: satellite encroachment, isolated clearings completely surrounded by the forest, and marginal encroachment, clearings at the interface between settlements and forest. The total area of marginal encroachment is more than that of the satellite encroachment. In general, the size of marginal encroachment areas is larger than that of the satellite encroachment areas.

It is not possible to identify the original vegetation of encroachment areas, because earlier aerial photographs are not available. However, by looking at the surrounding vegetation, clues about the intensity and causes of encroachment may be available. In Gera Forest encroachment tends to be of the satellite pattern with small individual clearings. Many satellite encroachment areas in Gera Forest are found in undisturbed and slightly disturbed forests. This indicates that the encroachment may be related to coffee production activities. In Belete Forest the pattern of encroachment was of the marginal pattern with clearings of large size. This encroachment probably due to the expanding of farmland and pasture, as a result of population pressure.

Encroachment areas generally occur on slopes of less than

30% slopes. A few encroachment areas are found on areas with slopes greater than 30%. Compared to Gera Forest, more encroachment areas are found on steeper slopes in Belete Forest. Again it indicates that Belete Forest is under pressure due to population growth.

The deforestation rate in the Belete-Gera Forest is about the same as in other parts of the world, 1.5% per year in southern Mexico and Central America, 1.6% in southeast Asia. Similar to the situation in other countries, encroachment is mostly related to roads and other corridors, such as rivers and oil pipelines in Guatemala (Sader *et al.*, 1997).

3 Coffee production

Based on DADO's estimation, 6,176 ha, 5.8% of the total forest land and 26.1% of the heavily disturbed forest land, are under coffee production activities. A detailed examination of the data revealed that in Belete Forest the area of coffee plantation is more extensive than that of the coffee collecting sites. In Gera Forest, however, the situation is reversed. This data is consistent with the fact that Belete Forest area has a higher population and is more accessible than Gera Forest area.

However, observations made by the authors and by local foresters suggest that the land area under production is actually much greater than what DADO estimated. During the forest survey, 25 out of 51 plots surveyed in the Gera Forest and

Table 3 Impact of coffee production on the species composition of Belete-Gera Forest.

Gera Forest				Belete Forest				Species
Frequency of				Frequency of				
Surveyed coffee plot		Undisturbed forest with coffee		Surveyed coffee plot		Undisturbed forest with coffee		
#	%	#	%	#	%	#	%	
2	40					2	50	<i>Albizia grandibracteata</i>
4	80	7	54	1	50	2	50	<i>Albizia gummifera</i>
5	100	7	54			1	25	<i>Allophylus abyssinicus</i>
		1	8			1	25	<i>Aningeria adolfi-friedericii</i> *
1	20	5	39	1	50	3	75	<i>Apodytes dimidiata</i>
3	60	1	8			3	75	<i>Bersama abyssinica</i> subsp. <i>abyssinica</i>
1	20	8	62	1	50	3	75	<i>Cassipourea ruwensorensis</i>
		7	54			3	75	<i>Celtis africana</i>
1	20			—	—	—	—	<i>Clausena anisata</i>
1	20	7	54	2	100	2	50	<i>Cordia africana</i> *
1	20	6	46	1	50	4	100	<i>Croton macrostachyus</i>
		2	15	—	—	—	—	<i>Dracaena steudneri</i>
2	40	3	23	—	—	—	—	<i>Ehretia cymosa</i>
		1	8	—	—	—	—	<i>Ekebergia capensis</i>
		2	15	—	—	—	—	<i>Elaeodendron buchananii</i>
1	20	1	8	1	50			<i>Euphorbia candelabrum</i>
—	—	—	—			1	25	<i>Ficus spp.</i>
1	20	5	39			2	50	<i>Ficus sur</i>
2	40					2	50	<i>Galiniera saxifraga</i>
		1	8	—	—	—	—	<i>Grewia bicolor</i>
		1	8	—	—	—	—	<i>Ilex mitis</i>
		1	8	—	—	—	—	<i>Landolphia owarensis</i>
2	40	2	15	—	—	—	—	<i>Macaranga lophostigma</i>
		2	15	—	—	—	—	<i>Manilkara butugi</i>
2	40	3	23			2	50	<i>Maytenus senegalensis</i>
1	20	4	31	1	50	2	50	<i>Millettia ferruginea</i>
—	—	—	—			4	100	<i>Mimusops kummel</i>
4	80	8	62	—	—	—	—	<i>Olea capensis</i> subsp. <i>hochstetteri</i>
2	40	12	92	1	50	4	100	<i>Olea welwitschii</i>
1	20	3	23	—	—	—	—	<i>Oxyanthus speciosus</i>
		1	8	—	—	—	—	<i>Pittosporum abyssinicum</i>
2	40	1	8			1	25	<i>Podocarpus falcatus</i> *
1	20	5	39	1	50	3	75	<i>Polyscias fluva</i>
1	20	2	15	—	—	—	—	<i>Premna schimperi</i>
1	20	4	31	1	50	3	75	<i>Pygeum africana</i>
		2	15			2	50	<i>Rothmannia urcelliformis</i>
		2	15	—	—	—	—	<i>Rytigynia neglecta</i>
2	40	4	31			1	25	<i>Sapium ellipticum</i>
3	60	9	69			1	25	<i>Schefflera abyssinica</i>
2	40	10	77	2	100	4	100	<i>Syzygium guineense</i>
5	100	10	77			3	75	<i>Teclea nobilis</i>
		2	15	—	—	—	—	unknown #1
		1	8	—	—	—	—	unknown #2
1	20			—	—	—	—	U-do (local name only)
1	20			—	—	—	—	saho (local name only)
1	20			—	—	—	—	ammabeyya (local name only)
1	20			—	—	—	—	babessa (local name only)

*Protected species.

5 out of 11 plots surveyed were found to have naturally grown coffee plants in the understory and to have been manipulated for coffee production activities. The forest surveyed ranges from undisturbed to heavily disturbed forest. We estimate that coffee bean collecting activity affects between 45 to 49% of the accessible natural forest.

Table 2 lists a summary of the coffee production site survey results. It is clear that coffee plantations have altered forest condition more than other types of production, reducing both

species diversity and tree density, especially in the lower and understory layers. There is no noticeable difference among the coffee collecting sites without managerial care and collecting sites with minimal management.

In Belete Forest the 1 year old coffee plantation site showed clear evidence of tree removal. Within the 10 m by 10 m subplot, a total 15 stumps of 7 species were tallied. Diameters of these stumps ranged from 2 cm to 20 cm.

Most common species found in Belete Forest coffee plan-

tation sites are *Syzygium guineense* and *Cordia africana*. While comparing the species list of coffee plantation sites to that of undisturbed forest where coffee grow naturally, four major species, *Mimusops kummel*, *Bersama abyssinica* subsp. *abyssinica*, *Celtis africana*, and *Teclea nobilis*, are missing in coffee plantation sites (Table 3). The species diversity is reduced in all three strata, but more significantly in the middle and lower layer of the forest. The total number of trees per hectare ranges from 43 to 65 in undisturbed forest, but only 12 to 20 in the coffee plantation sites (Table 2, 3).

Albizia gummifera, *Allophylus abyssinicus*, *Olea capensis* subsp. *hochstetteri* and *Teclea nobilis* are the species most frequently found in Gera Forest coffee bean collecting sites (Table 3). Comparisons with the undisturbed forest where coffee plants grow naturally were made, but no major differences were found except for the species *Celtis africana*, which is frequently found in undisturbed forest but not found in the coffee bean collecting sites. Three species, *Albizia grandibracteata*, *Galiniera saxifraga*, and *Clausena anisata* are found in coffee collecting sites, but not in any of the undisturbed forest survey plots. As for the total number of species and density, the coffee collecting sites are all within the range of undisturbed forest survey plots, but in the low range (Table 2).

4 Conclusion and management implications

Population pressure, lack of awareness and weak management are identified as the major causes for the deforestation and degradation of natural resources in the area. Invasion of natural forest for expanding farm land/grazing field and coffee production has severely impacted the forest. An inventory of encroachment, totally 8,615 ha and 291 areas, has been set up to facilitate the effort to re-locate encroachers. The extent of coffee production activities has been estimated as 45–49% of the total accessible forest. Coffee plantations have the most adverse impact on the forest by reducing the density from 43–65 trees/ha to 12–20 trees/ha, and changing the species richness of the forest from 11–20 species/ha to 6–7 species/ha.

Studies on the encroachment and coffee production activities imply that management strategies should take both governmental (top-down) and communal (bottom-up) approaches. Authorities and guidelines established by the government are essential since the composition of local residents has been changed and people have lost their ties to the land. The community approach is important because of local people's dependence on natural resources, and population pressure and hardship can not be alleviated in a short period of time.

A 10 year study made in Brazil shows that the intercropping of coffee and *Grevillea robusta* at a density of 26, 34, and 48 trees/ha didn't decrease the yield of coffee and economic gains can be expected from sites with 34, 48, 71 trees/ha (Baggio *et al.*, 1997). An agroforestry approach, especially intercropping coffee and *Cordia africana* and other endangered timber species, should be introduced into this area to benefit both the forest and the coffee production.

Authority on the Forest should be established and man-

agement activity in the Forest is a strong indication of authority. Local people usually do not encroach forest plantations and logged sites where artificial regeneration have been conducted in a timely manner. Similar observation was reported in Muneshasha Forest (Jirane, 1998, personal communication). Other declarations of authority include patrolling, clearly defined and maintained boundaries, uniforms, notifying local residents on the logging and regeneration methods and schedules, ... *etc.*

Patrolling should be intensified in the seasons before planting of crops and coffee plants, during and after coffee bean collecting season and after logging, since encroachment is mainly related to those activities. In general, the number of personnel and mobility for patrolling should be increased, since experience in other countries showed that enforced patrolling has been one of the effective ways to control encroachment (Sader, 1997).

Forest boundaries should be made clear and easily identified in the field, (using topographical or natural features, permanent monuments, plantations or signs), especially in areas near villages and along roads and foot paths. Most of the encroachment occurred in those areas.

Settlers and school children should be provided with information on the values of forest and local natural history to raise their awareness of forest protection.

As for coffee production, a clearly defined jurisdiction and coordination among governmental agencies are essential. A registration/permit system should be established to quantify the type and extent of management. Regulations should be set up on coffee production activities based on forest conditions and ecological principles, especially for coffee plantation areas.

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